THE ONTARIO WATER RESOURCES COMMISSION

GEOLOGY OF THE UPPER PART OF THE SEVERN RIVER BASIN AND THAT PART OF THE SEVERN RIVER BASIN LYING WITHIN THE HUDSON BAY LOWLAND

NORTHERN ONTARIO WATER RESOURCES STUDIES

JANUARY, 1970

135 ST. CLAIR AVE. WEST - TORONTO

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GEOLOGY OF THE UPPER PART OF THE SEVERN RIVER BASIN AND THAT PART OF THE SEVERN RIVER BASIN LYING WITHIN THE HUDSON BAY LOWLAND

By: R. G. Wilkins

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* * *

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GEOLOGY OF THE UPPER PART OF THE SEVERN RIVER BASIN AND THAT PART OF THE SEVERN RIVER BASIN LYING WITHIN THE HUDSON BAY LOWLAND

INTRODUCTION

During the 1969 field season, studies were carried out in the upper part of the Severn River basin west of 93° 00' W and the lower part of the basin north of a line running diagonally across the basin from 55° 00' N in the west to 54 00' N in the east (see Figure 1). This latter area is commonly known as the Hudson Bay lowlands. Since these two areas are approximately 200 miles apart and geologically dissimilar, they were surveyed individually and therefore described in this report in two separate sections. Geologic sections observed in the Severn River basin during the 1968 and 1969 field season are described in the Ontario Water Resources Commission's publications, Water Resources Bulletins 1-1 and 1-2.

Field work was carried out using a Cessna 180 aircraft for low-level aerial reconnaissance, landing at approximately 10 to 15 mile intervals to conduct ground checks. This method of traversing is quite successful in areas such as the Severn River basin where large

Location Map
of
Areas of Study

Scale 1 inch to 50 miles

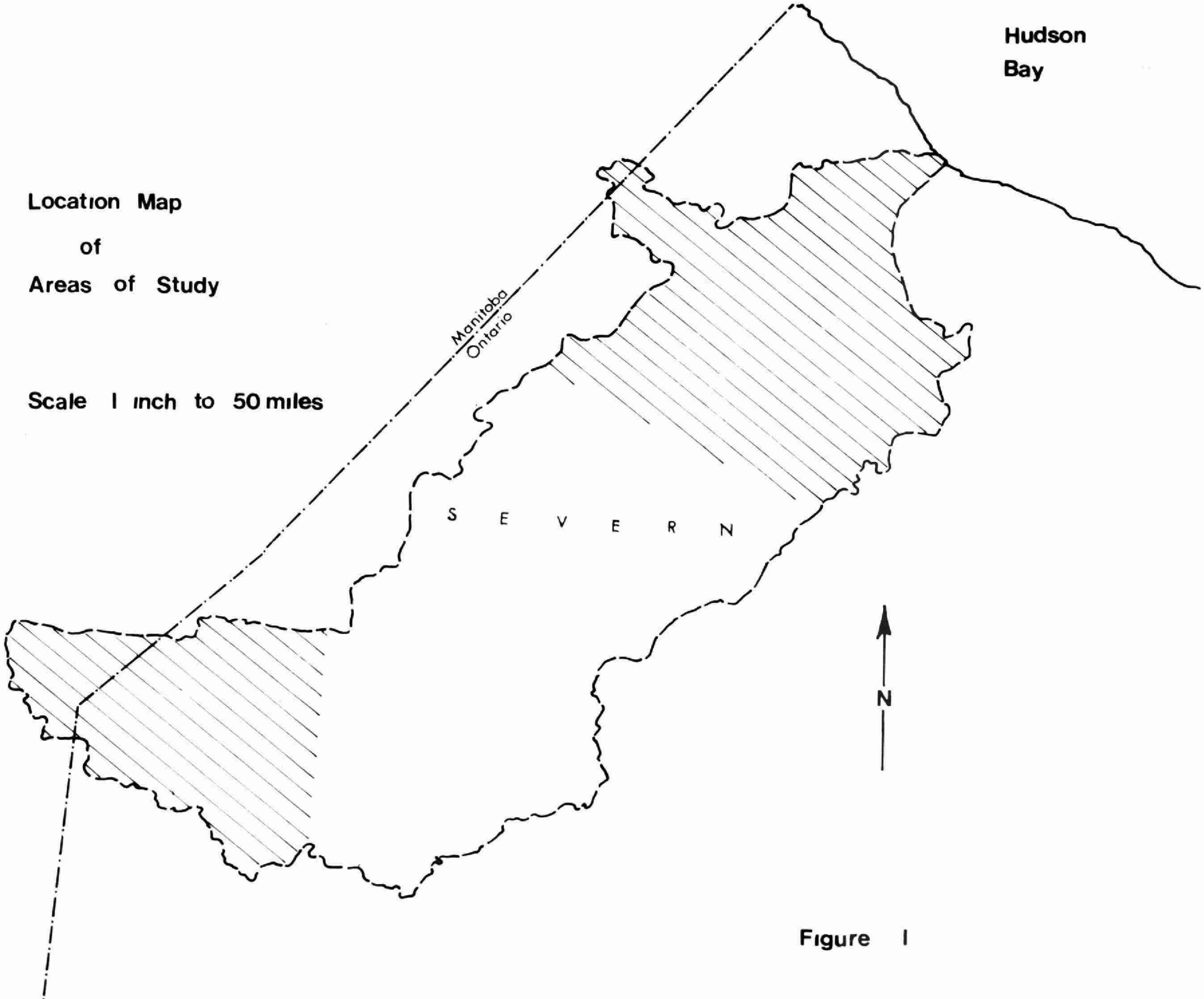

Figure 1

areas must be surveyed, geology is relatively simple and rapid changes do not occur. Use of aerial photographs, aerial mosaics and published literature was made during office studies that preceded and followed the summer's field activities.

GEOLOGY OF THE UPPER PART OF THE SEVERN RIVER BASIN

Geomorphology

The upper part of the Severn River basin can be divided into two parts, the bare bedrock areas and the area of lacustrine deposits. The transition between these two areas occurs along a line running eastwest at approximately 53° 00' N. South of this line is the bedrock area. This is a region of rugged topography. Bare bedrock makes up approximately 80 to 90 per cent of the ground surface in the form of well-rounded, smooth knolls and hills. These hills are separated by valleys of varying size, often filled with lakes or swamps. Open water surfaces were estimated to cover 40 to 50 per cent of the land surface.

In the bedrock areas, the rivers and streams characteristically contain many stretches of fast water, rapids or falls. Fault control of river channels in this

area is a prominent feature. Similarly, lakes in the region are long, narrow and deep since water collects in faulted rock areas where preferential erosion has resulted in depressions in the rock and where ground-water flow is possible through the fault zones.

In the area of lacustrine deposits, swamps and muskeg are the dominant features due to the low transmissiblity of these deposits which impedes drainage of the very flat ground surface. The monotony of this terrain is broken only by the occasional bedrock 'island' sticking up above the surrounding, otherwise monotonous, terrain. Open bodies of water are not as prominent as in the more rocky areas. Lakes in the area are generally larger in surface area, but are very shallow, often less than 10 feet maximum depth. Water in these lakes is a cream-brown colour, due to suspended clay particles derived by erosion of surrounding lacustrine deposits. Rivers in this area tend to be wide, shallow and meandering.

Bedrock Geology

The upper part of the Severn River basin is underlain predominantely by granitic rocks with local 'greenstone' belts and minor metamorphosed sediments and basic rock outcrops (see Figure 2).

Acid rock underlies approximately 85 per cent of the study area. These rocks are massive granites and grano-diorites emplaced during the Kenoran orogenic episode approximately 2,390 million years B.P. (Stockwell, 1965). Belts of metamorphosed volcanic rocks of similar age are also found in the study area; rhyolite, andesite, basalt and pillow lavas. One of these belts runs along the north shore of Sandy Lake and then swings north up the Rottenfish River. A second belt runs along the north shore of Favourable Lake and then in a southeast direction to Setting Net Lake. Local volcanic outcrops are found at McInnes Lake and Hornby Lake and in association with metamorphosed sediments in the North Spirit Lake area.

Also found in the area are belts of metamorphosed sedimentary rocks; metamorphosed greywacke, quartzites, conglomerates and iron formation of Archean age. One such belt runs from the vicinity of Hudwin Lake in Manitoba, east almost to Favourable Lake. A second such band, with a northwest, southeast trend, is situated at Whiteloon Lake.

A minor exposure of basic rock is found at Favourable Lake. These rocks range lithologically from gabbro to diorite with the ultrabasic rock hornblendite

also present.

Historical Geology Pleistocene History

Approximately 9,000 years B.P. (Prest, 1963), glacial melt water trapped between the height of land and the ice-front lay as a vast lake across the upper part of the Severn River basin, its margin following the retreating ice-front in an easterly and northeasterly direction. This pro-glacial lake was Lake Agassiz. It covered a large portion of central western Ontario and drained into the Mississippi system via the Red River.

The waters of this lake were responsible for erosion of glacial debris from high areas and the subsequent deposition of the fine fraction of this material in the low areas and the construction of beaches from the coarser fractions along the flanks of bedrock hills and the slopes of preserved glacial deposits.

A subsequent re-advance of an ice-lobe from the east produced a moraine which runs from Lac Seul northwest to Trout Lake and then swings northeast to MacDowell Lake. This moraine is the Lac Seul moraine (Prest, 1963). When this lobe of ice again retreated, the melt water lake expanded, following the retreating ice front almost to 92°W. The retreat of the ice

reopened drainage channels to the south into the Lake Superior basin, with a resultant decrease in size and finally, complete disappearance of the glacial lake.

Description of Surficial Deposits

Glacio-lacustrine Deposits

The most prominent surficial deposits in this area are the lacustrine clays and silts (see Figure 3). These deposits are a cream-brown colour silt and/or clay in varying proportions. They vary in thickness from zero to 30 or 40 feet and are massive or varved in nature. When varved, they consist of light brown clay winter strata and darker brown or brown-black summer strata of clay and silt, silt, or very fine sand (Flint, 1956). Varves, observed at Angekum Lake and Varveclay Lake, vary in thickness from one-quarter inch to several inches. These glacio-lacustrine deposits have a large areal extent, running from the western side of the study area to the eastern side and south to 53°N latitude.

Boulder beaches built up along the flanks of various glacial deposits are found in most locales where these glacial deposits came under the influence of wave action from the waters of the pro-glacial lake. They were observed to consist of two types; scattered lag deposits of boulder and cobble size rock fragments,

loosely strewn across the ground at a set elevation, and tightly packed formations of boulders of one size range, similarly found as a band at a specific elevation. Both types of deposit can be observed in modern lakes, the tightly packed formation possibly being a final product of the scattered, loose formation.

Ground Moraine

Ground moraine is found along the eastern edge of the study area where reworking by the waters of glacial Lake Agassiz was minimal either as a result of being protected by ice or because it was above the elevation of the lake. This material is a sandy till, that is to say a poorly sorted, unstratified, heterogeneous aggregation of angular to sub-rounded sand, gravel, cobbles and boulders. Thickness of this deposit varies from zero to 20 or 30 feet, and has an undulatory surface. Muskeg has developed where drainage is poor and outcrops are also found scattered throughout the area.

End Moraine

The Lac Seul moraine is located in the south-eastern corner of the study area just west of MacDowell Lake. The end moraine is of the same composition as the ground moraine, as it is a thickening of the latter deposit caused by a halt in the retreat of the ice mass.

In this area, it has been modified by wave action, producing boulder beaches along its flanks and local concentrations of cobbles and boulders.

The Sachigo moraine is located in the northeast of the study area. It has been described by G. Hamilton in his report, "Geology of the Severn River Basin" (1968).

Minor Moraines

These deposits are found in fields along the eastern border of the study area in the transition zone between lacustrine deposits and ground moraine.

They consist of ridges up to half a mile long, a few hundred feet wide and 15 or 20 feet high. They run in a direction transverse to the direction of ice movement. In the study area, the minor moraines are often covered by a boulder armour as a result of reworking by the waters of the glacial Lake Agassiz.

These deposits are believed by some to be formed when the ice mass enters a body of standing water (Prest, 1968). The spatial relationship between ground moraine and lacustrine deposits, in this case, supports this hypothesis. Others believe them to be formed by seasonal differences in the rate of retreat of the ice

(Lawrence and Elson, 1953).

Glacio-fluvial Deposits

Eskers were not observed in the western part of the study area. If they were originally present, they have been obliterated by the wave action of glacial Lake Agassiz. In the east, they are found in the area of ground moraine deposits. They are oriented in a northeast-southwest direction. They are in the form of stratified or unstratified ridges of well-sorted or poorly-sored sand, gravels and cobbles. In areas where they have been modified by lake action, they are covered by an armour of boulders and cobbles.

Hydrogeology

Bedrock

As was discussed in the section entitled "Geomorphology", the southern part of the Upper Severn River basin contains a very high percentage of bare crystalline rock. This bedrock is capable of transmitting and storing very little ground water since the only spaces available for water movement are void spaces created by solution of minerals and fault zones or joints. The former spaces are of little value since the pore spaces are not generally inter-connected. The latter spaces are strongly anisotropic and only local in extent.

As a result of this impermeability, no deep ground-water flow system and low storage coefficients can be expected. Precipitation reaching the bare bedrock surfaces either runs off immediately into the lakes and rivers, or infiltrates into the shallow unconsolidated deposits found in this area. These deposits probably contain shallow local flow systems. Flow patterns will either be down slope to the nearest body of water or into isolated depressions in the rock (see Figure 4). Some of the water probably infiltrates into sheared zones or joints and hence find a route to rivers in this manner.

Surficial Deposits

The lacustrine deposits in the area, being composed of fine sand, silt and clay, have relatively high porosities and low permeabilities. Evidence of this fact is the large swamps found in association with these deposits. Infiltration of water in these areas is very slow and is further hindered by the build-up of peat in the muskeg swamps; however, clays have a high water storage capacity. Probable yields of ground water from these deposits will be low, although horizontal flow through the coarse varves will be greater than the vertical flow across the varved strata.

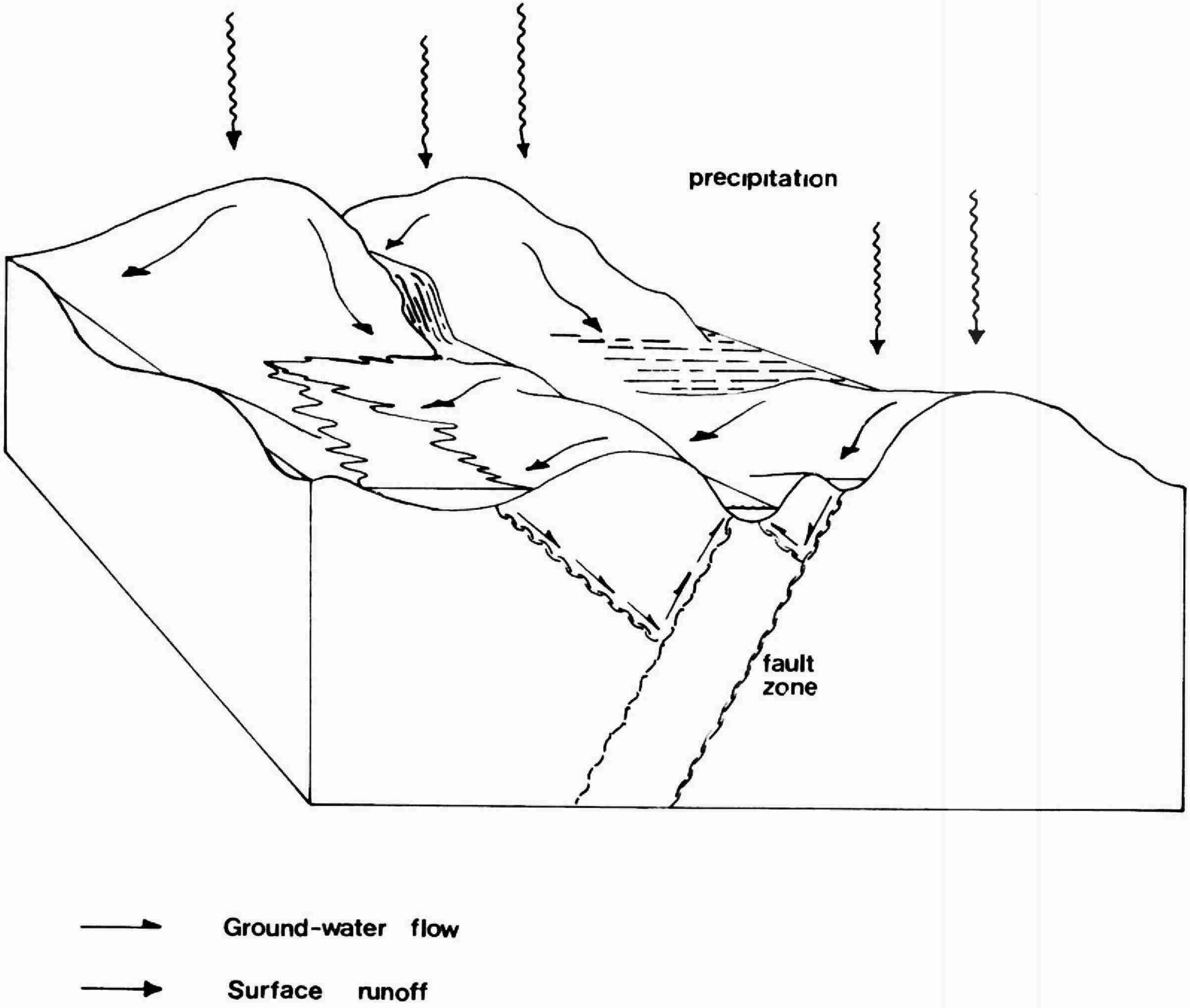

Figure 4 Possible ground-water flow pattern in the upper Severn R. basin

Glacio-fluvial deposits are composed of material which is generally coarse-grained and often well-sorted. These deposits, therefore, will have a relatively high porosity and permeability; however, the esker deposits are higher in relief than the local terrain and, therefore, are easily drained of water so that there is probably only a thin saturated zone at the base of most eskers.

Sandy till in the study area, in the form of ground moraine, minor moraine and end moraine is a poorly-sorted mixture of a variety of grain sizes. It will, therefore, have a relatively moderate porosity and permeability; however, this material is often too thin, especially where it is in the form of ground moraine, to have a large storage capacity and therefore cannot be considered a valuable aquifer.

GEOLOGY OF THE LOWER PART OF THE SEVERN RIVER BASIN LYING WITHIN THE HUDSON BAY LOWLANDS

INTRODUCTION

That part of the Hudson Bay lowlands that lies within the Severn River basin was found to be physiographically, stratigraphically, lithologically and hydrogeologically very similar to that part of the James Bay lowlands lying within the lower Albany River basin studied in 1968 by members of the Division of Water Resources, Surveys and Projects Branch. That is to say, events that brought about the geologic conditions in the lower Albany basin also occurred in the lower Severn; the retreat of the ice front at the end of the Wisconsinan glaciation was followed by inundation of the land by the sea and a subsequent re-emergence of this drowned land.

GEOLOGY OF THE LOWER PART OF THE SEVERN RIVER BASIN

Geomorphology

The lower Severn River basin is an area of extremely low, even relief. The area slopes gently towards Hudson Bay at a rate of approximately three feet per mile. Rivers in this area are often quite shallow and contain

few rapids, with the exception of places where they have cut down to bedrock. The rivers are often found in entrenched meanders caused by the rapid rate of uplift due to isostatic rebound in this area.

There are fewer lakes in this area than in the regions farther upstream; however, the ground surface is extremely wet due to water being trapped in muskeg swamps and string bogs. This muskeg is observed to be generally 3 or 4 feet deep and occasionally up to 10 feet deep. The monotony of the area is increased by the tendency of the muskeg to fill in depressions, thus increasing the flatness.

The only relief is provided by raised or abandoned beaches up to 20 feet above the surrounding terrain, left by the marine transgression and regression; levees along the banks of the rivers and slightly elevated, plateau-like hillocks, possibly a form of pingo or frost boil. Specific examples examined at Sombert Lake were found to contain perma-frost. They had an elevation 4 to 6 feet above the surrounding terrain and were several hundred yards in diameter. Other examples observed from the air in the lowland area were covered with trees and may be the final product of the land-form noted at Sombert Lake. Trees are able to grow on these rises because the

ground, being higher, is drier than the surrounding muskeg.

Bedrock Geology

This part of the basin is underlain entirely by rocks of Paleozoic age belonging to the Ordovician and Silurian systems (see Figure 2). These formations have a regional dip to the north-northeast.

The oldest Palezoic rocks in this basin are the Bad Cache Rapids Group belonging to the Ordovician System. This group consists of sandstones, limestones and dolomitic limestone (Sanford, Norris and Bostock, 1967).

Overlying the Bad Cache Group is the Churchill River Group. This group consists of Ordovician micro-crystalline or crypto-crystalline limestone and dolomitic limestone.

Lying conformably on the Ordovician sediments are Silurian strata of varying lithologies. The oldest Silurian rocks belong to the Severn River Formation. These rocks are crystalline limestones and dolomites. Overlying the Severn River Formation is the Ekwan River Formation. It is a crystalline limestone and dolomite and is locally bituminous in nature (Sanford, Norris and Bostock, 1967). The next youngest formation is the Attawapiskat Formation.

These are reef structures or biohermal limestones and associated inter-reef limestones and dolomites. The youngest formation is the Kenogami River Formation. Only the lower two members of the formation are present in the Severn River basin. The lower member consists of crystalline dolomite. This dolomite grades into the second member which consists of mudstone, silstone, dolomite and limestone.

There are very few outcrops in the lowland area of the Severn River basin. Where observation was possible, these sediments were all flat-lying or dipping slightly to the north and are highly fractured. This fracturing may be due to freeze-thawing and possibly does not continue to depth.

Historical Geology (Pleistocene History)

In contrast to areas farther south that were repeatedly glaciated and then ice-free during interstadials, the Severn River area, due to its northern latitude, was covered by relatively inert ice during Wisconsinan time. Approximately 8,000 years B.P., the ice mass retreated out of the area for the last time. This retreat was immediately followed by innundation of the land which had been left below sea-level due to depression by the weight of the

ice upon it. As the land began to recover from the off-loading of the ice mass, the sea regressed. This regression is still continuing today and is responsible for the many abandoned beaches observed in this area.

Surficial Deposits

Marine Deposits

Raised beaches consisting of horizontally bedded deposits of sand, gravel and cobbles are found in the lowland area in the form of ridges, approximately 20 feet high, several hundred feet wide, and often a mile or more long. They increase in number towards the coast of Hudson Bay. Near the coast, they run parallel to the coastline, whereas farther inland they have a variety of orientations (see Figure 3).

The sea that flooded the lowland area after deglaciation deposited the following general sequence (youngest to oldest): a light brown horizontally bedded silt on very fine sand, sometimes containing marine shells; a medium sand to medium gravel, horizontally bedded or massive, sometimes containing marine shells; a blue-grey silty clay, sometimes containing marine shells. The silt is generally about 4 or 5 feet thick, while the gravel is not more than 2 feet thick. The

observed thickness of the silt-clay stratum varies.

Clay Till

Clay till is found in river bank sections along the southern edge of the lowland area and underlying the marine sediments at some locations. It is more common as a basal unit in the south and is seen less frequently in the direction of Hudson Bay. It has a light brown silty clay matrix containing rock fragments of the sedimentary rock found in the area. These fragments are generally coarse gravel size. The till is generally massive, but sometimes displays fractures running vertically and horizontally.

Sandy Till

Sandy till is found in some locations along the southern edge of the study area. It is derived from the Pre-Cambrian bedrock found in these areas. This till consists of a fine to medium sand matrix containing angular to sub-angular rock fragments, which are generally lithologically similar to the local bedrock. These rock fragments range from gravel to boulder size. The till has a light grey colour when fresh and weathers to a golden-brown colour. Thickness of these deposits varies.

Hydrogeology

Bedrock

Sedimentary rocks found in the lower part of the Severn River basin have a high permeability due to secondary porosity, that is to say porosity produced by solution of joint patterns, faults and bedding planes. These openings in the rock are produced after the rock has been formed and are further enlarged by solution of mineral grains along the openings. Near the surface, the rock fractures are more prevalent, possibly due to freeze-thawing action in the spring and fall. They may also be more common at the surface since surface rock doesn't have the weight of overlying rock to hold the cracks together. At depth fractures in the rock may die out completely.

Being highly fractured and containing no strata that might impede the transmission of water, it is reasonable to assume that water entering the bedrock flows through the fracture system down dip towards Hudson Bay (see Figure 5). Transmissibilities and specific capacities of these formations are unknown since there are no wells in the lower Severn River basin.

Surficial Deposits

A secondary local flow system is possibly present in the lowlands area. Precipitation reaching the ground is stored in the dense mat of organic material found in the lowlands. This water along with the free water on top of the muskeg is available to flow through the underlying clay deposits and into the regional bedrock system or may flow via the surficial deposits towards local rivers or lakes. Evidence of this local flow was observed in the form of seeps in the banks of the Severn River 12 miles above its confluence with the Fawn River and in the banks of the Sachigo River 24 miles above its confluence with the Beaverstone River. General hydrological characteristics of the various surficial deposits are described in the following paragraphs.

Marine deposits can be divided into two types, beach ridges and marine silts and clays. Beach ridges occur sporadically in all parts of the basin affected by marine submergence, but are especially frequent along the present coast of Hudson Bay. As they are formed from rounded to sub-rounded gravels and sands, they will have relatively high porosities and permeabilities;

however, these deposits sit on top of the surrounding clays and, therefore, will drain easily so that it is expected that only a thin layer at the base of the beach ridge will be saturated with water.

The marine silts and clays in the study area are very dense materials, especially the clay which is located beneath the silt in the stratigraphic section. The silt, being on top, has been more altered by frost, chemical weathering and root action, and therefore will be more porous. Both of these deposits, however, since they are quite dense, will have relatively low porosities and permeabilities. As was discussed earlier in the section "Surficial Deposits", a band of gravels is commonly observed in the river sections. This gravel appears to have a large areal extent; however, its small thickness limits its value as an aquifer.

Clay till in the study area has a high porosity and a low permeability due to the size and shape of the particles involved. This material, along with the marine silts and clays presents a formidable barrier to the downward passage of water, as is shown by the vast muskeg swamps and string bogs in the lowland areas.

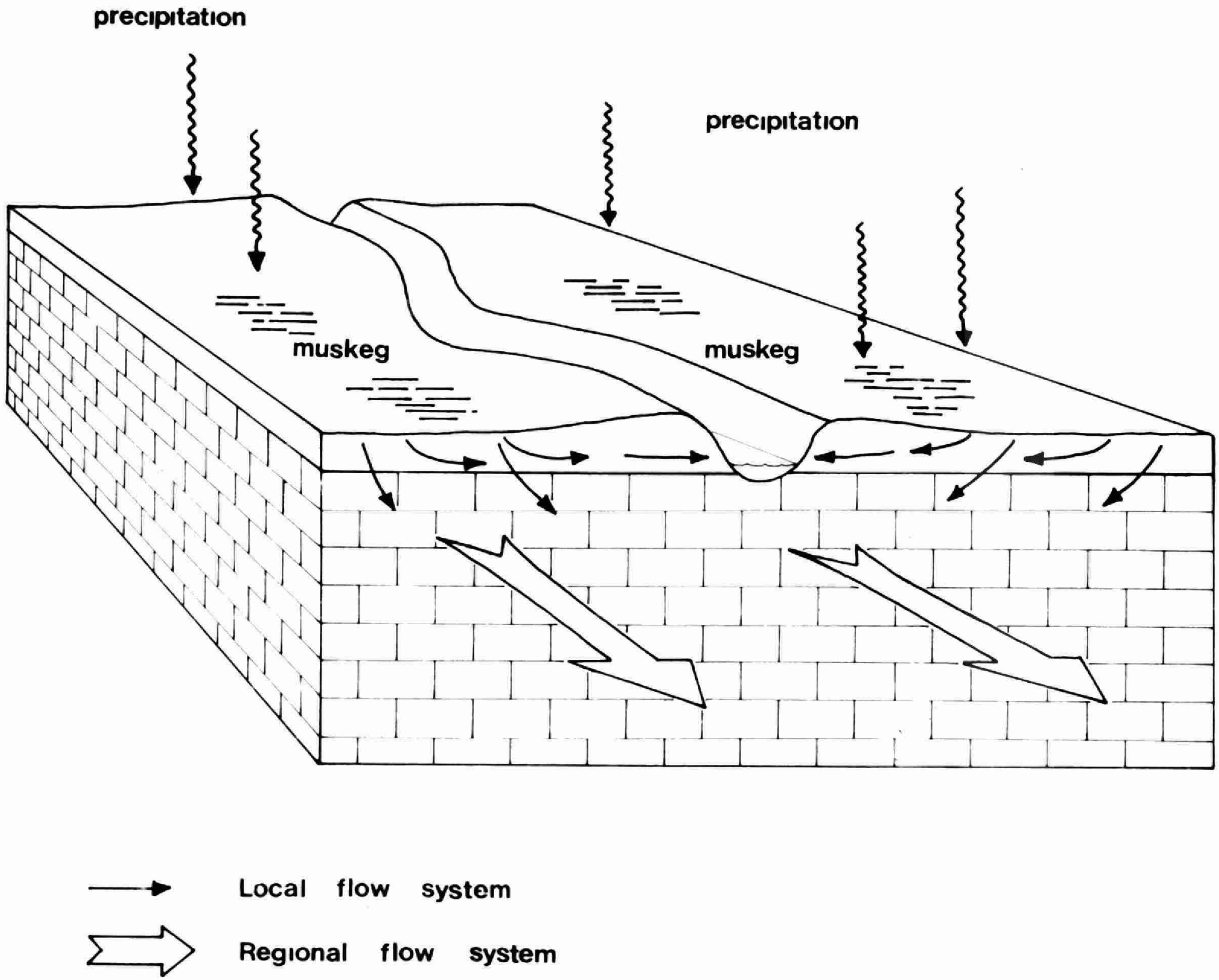

Figure 5 Possible ground-water flow pattern in the lower Severn R. basin

Sandy till in the area has a high porosity and high permeability due to the relatively large size of the particles involved and their variety of sizes. Since these deposits are often found in local isolated pockets, they are of limited value as a contributor to the regional flow system and are probably only of significance to the local ground-water flow pattern.

A unique barrier to the movement of water is perma-frost. On August 11, 1969, at Sombert Lake in the lowlands, permanently frozen ground was observed at a depth of four feet below the surface. The effect of this phenomenom on the movement of water in areas north of 55^{o}N should be investigated at a future date.

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BEDROCK GEOLOGY of the UPPER PART of the SEVERN RIVER DRAINAGE BASIN

scale: 1:500,000

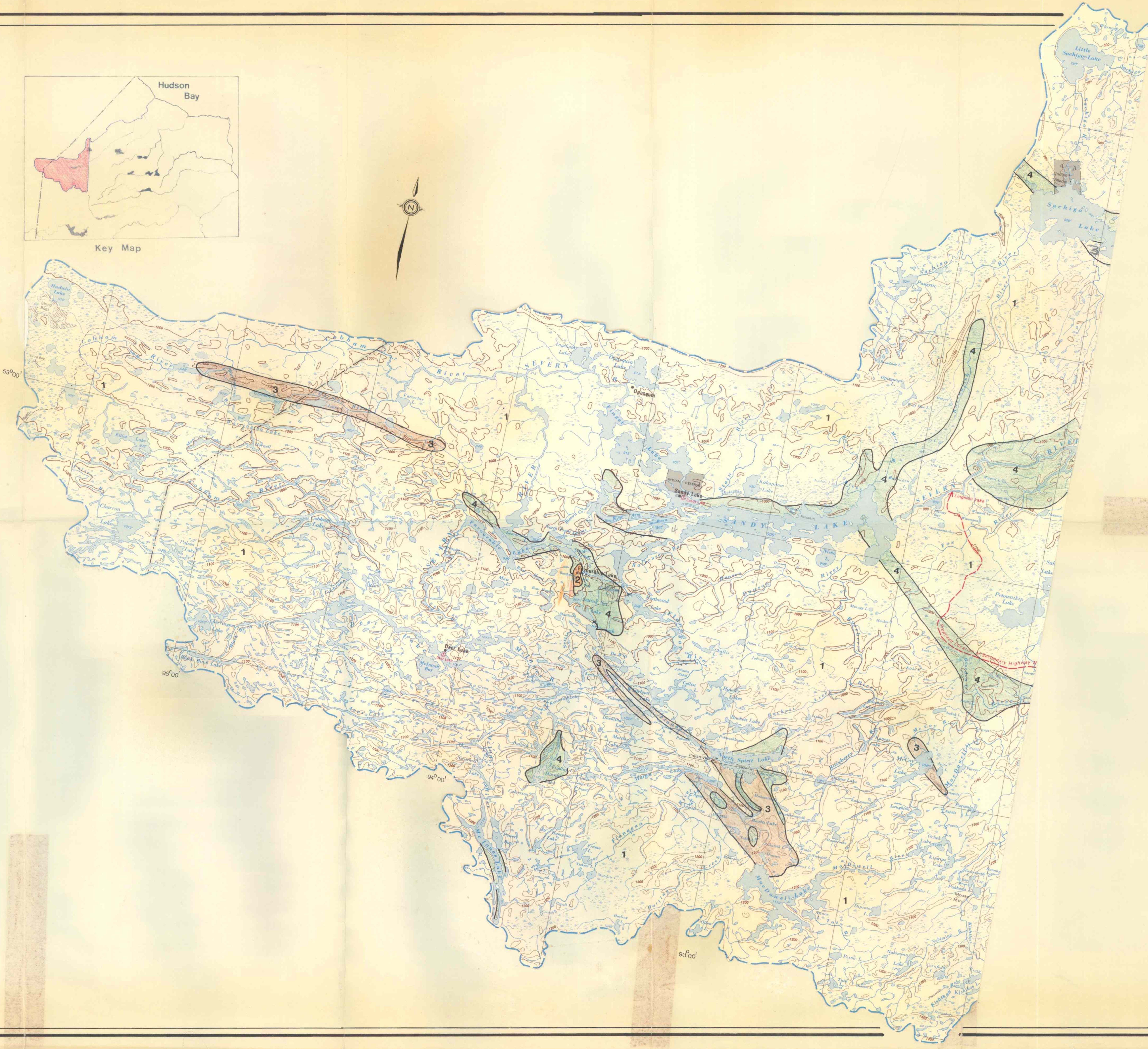
LEGEND

1. Igneous acid intrusive rocks: granite, syenite granite gneiss.

2. Basic or ultrabasic intrusives: diorite, anorthosite, gabbro, peridotite, dunite.

3. Metamorphosed sedimentary rocks: greywacke, arkose, quartzite conglomerate, iron formation.

4. Volcanic rocks, basalt, andesite, rhyolite, pryroclasties.



Key Map

Sources of Information

Bedrock geology information is from Ontario Department of Mines Map 1958 B, and field observations.

Figure 1

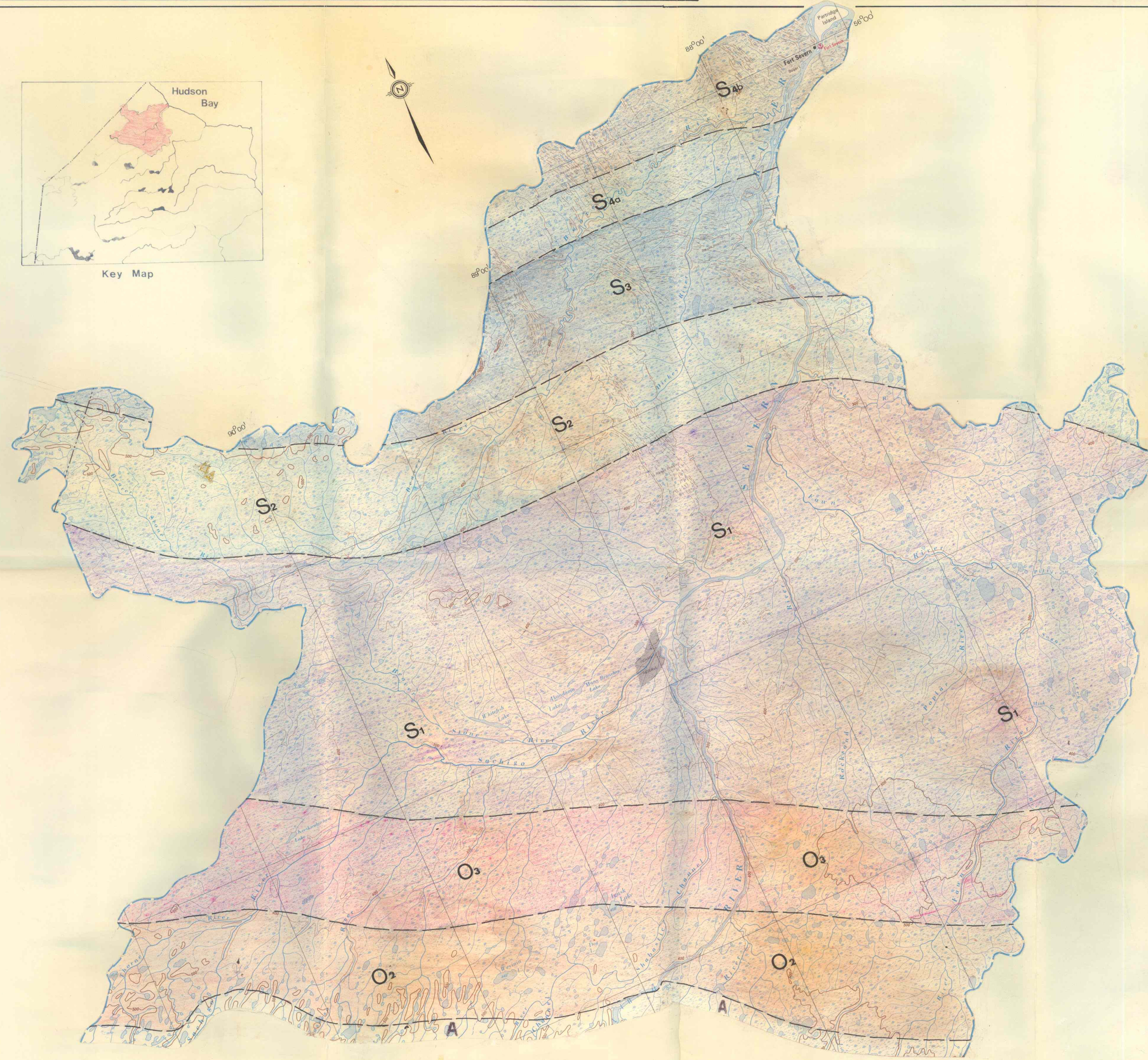
BEDROCK GEOLOGY
of the
LOWER PART
of the
SEVERN RIVER DRAINAGE BASIN

scale: 1:500,000

Key Map

LEGEND

- S_{4b} Middle Member Kenogami River Formation: red siltstone shale mudstone
- S_{4a} Lower Member Kenogami River Formation: yellowish-orange limestone
- S_3 Attawapiskat Formation: reefal limestone
- S_2 Ekwan River Formation: brown fossiliferous limestone and dolomite
- S_1 Severn River Formation: dolomite, shaly dolomitic limestone
- O_3 Churchill River Group: brown limestone
- O_2 Bad Cache Rapids Group: sandstone, fragmental limestone, dolomitic limestone
- A Igneous acid intrusive rocks
- — — — Assumed geologic contacts



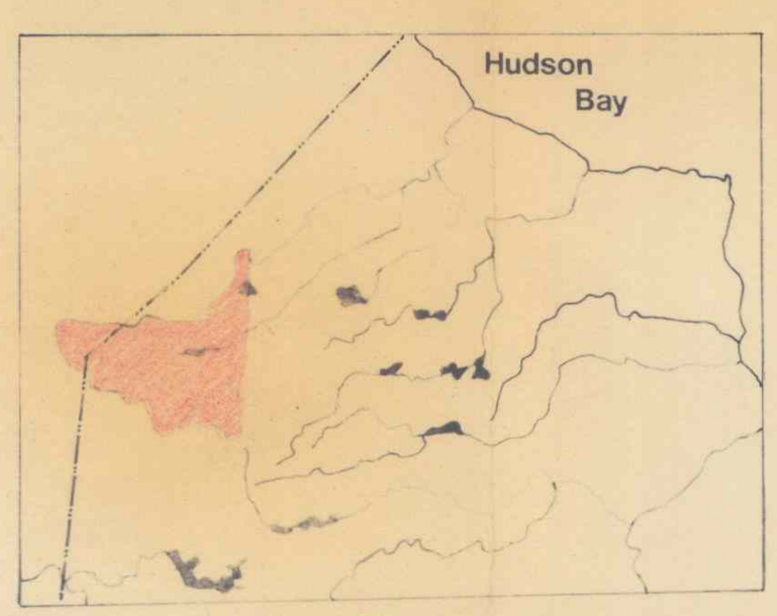
Sources of Information

Bedrock geology information is from Geological Survey of Canada Map 17-1967 and field observations.

Figure 3

SURFICIAL GEOLOGY of the UPPER PART of the SEVERN RIVER DRAINAGE BASIN

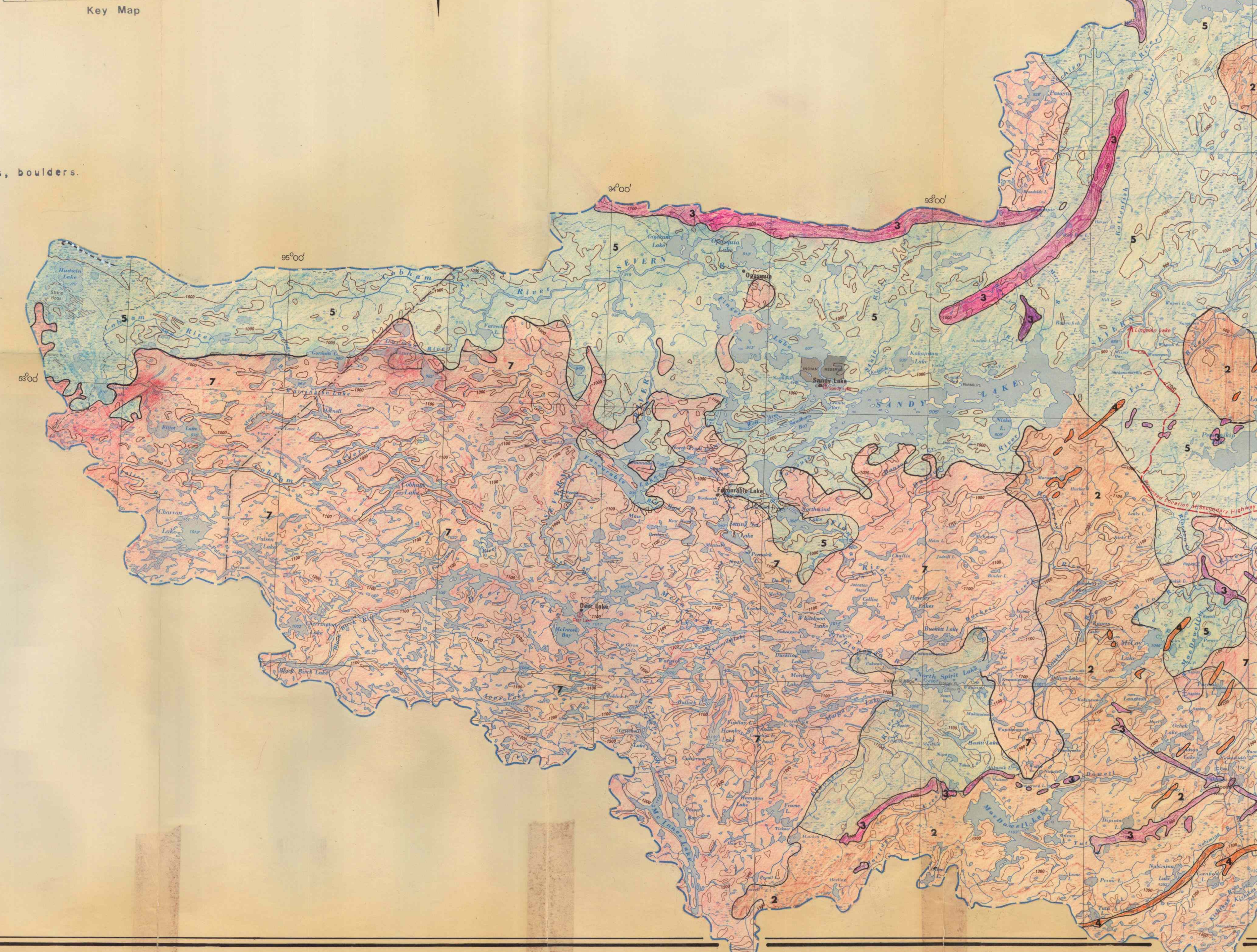
scale: 1:500,000



Key Map

LEGEND

1	Ground moraine; clayey to silty till.
2	Ground moraine; silty to sandy till.
3	End moraine; silt, sand, gravel, boulders.
4	Esker or esker complex; sand, gravel cobbles, boulders.
5	Lacustrine deposits; clay, silt, fine sand.
6	Marine deposits; clay, silt.
	Raised beach deposits; sand, gravel, cobbles.
7	Bare bedrock



Sources of Information

Surficial geology information is from Geological Survey of Canada Map 5-1963, Ontario Department of Mines Map No. 35 f and field observations by G. Hamilton and R. Wilkins.

Figure 24

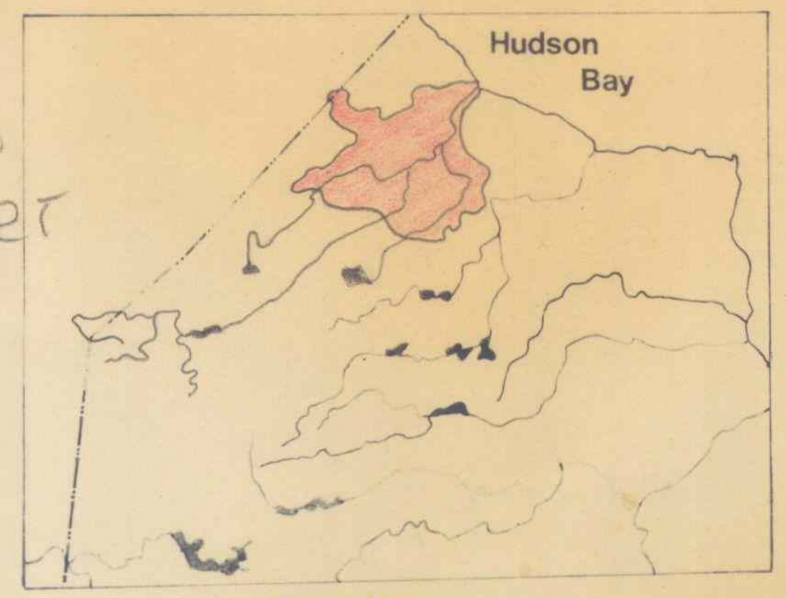
SURFICIAL GEOLOGY

of the

LOWER PART UPPER AND LOWER PART

of the

SEVERN RIVER DRAINAGE BASIN



Key Map

scale: 1:500,000

LEGEND

1	Ground moraine; clayey to silty till.
2	Ground moraine; silty to sandy till.
3	End moraine; silt, sand, gravel, boulders
4	Esker, esker complex; ~~sand, gravel, cobbles, boulders.~~
5	Lacustrine deposits; clay, silt, fine sand.
6	Marine deposits; clay, silt.
	Raised beach deposits; sand, gravel, cobbles.
	~~Bare bedrock~~ Areas of extensive bedrock exposure
S	~~Seep~~ Seep
	Raised beaches

Sources of Information

Surficial geology information is from field observations by G. Hamilton and R. Wilkins.

GEOLOGICAL SURVEY of CANADA MAP 5-1963, Ontario

DEPARTMENT OF MINES MAP NO. 35f and f .....

Figure 4